10.6 billion dollars and net profits of almost 1.3 billion. Acquiring a neat little software company with annual profits of 10 million dollars does not do much for an RHC's earnings, especially if you are looking at declining profits in the regulated areas that produce 90% of RHC revenues.

All of the foregoing leads me back to my opening. Telephone companies traditionally made money because of their "deal" with the State. The lion's share of any telco's assets and expertise is invested in the regulated telephone sector. Making and keeping more money means leveraging those assets and expertise. And that means cutting a new deal with the State. If there is a single major solution to telcos' financial woes, it lies here.

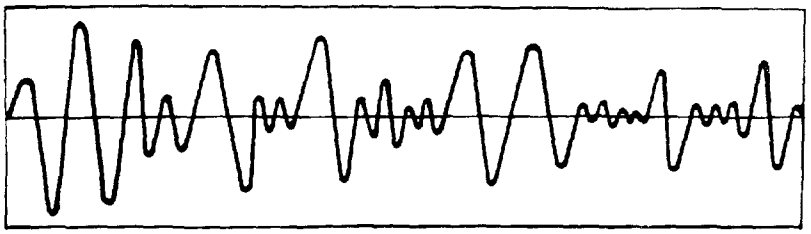
I know that many companies have tried and are trying to craft new deals under a variety of labels. But I also would contend that few telcos have given the new deal-making activity a priority commensurate with its financial importance to the companies in the industry. Few have given the regulated core telephone business the same imagination and top management attention that they have been willing to invest in unrelated industries or overseas experiments. Too many telephone company executives still do not recognize the importance and urgency of coming to new terms with state regulators and other state and federal politicians that write the rules of the game.

Telecommunications is a business enjoying vast growth rates, and most telecommunications is local. You are local telecommunications companies. I think that if I were in your shoes, I would be spending about 90% of my management time and attention working with my regulators to come up with some new rules that allow my company to make money, and allow the regulators to look like winners, too. If you and your colleagues cannot envision such new arrangements, then I would suggest that top management devote most of its time to figuring out how one drastically down-sizes a telephone company. I suspect that is the remaining option.

Science Times

The New York Times

U.S. Counts on Computer Edge In the Race for Advanced TV



Transmission of continuous signal

Transmission of digital signal

Digital Transmission for High-Definition TV

Experts say the future of television lies in digital processing, which can increase accuracy and scope of electronic systems. Digital processing deals in a simple code, like that represented by black and white bars, above. In contrast, an analog signal, top, varies continuously and is much more susceptible to being overwhelmed by interference.

Source: A.T.& T. Bell Laboratories

Efforts focus on digital signals for broadcast channels.

By WILLIAM J. BROAD

DESPITE a slow start by the United States in the race to build television sets with razor-sharp pictures, a growing group of scientists and engineers say there is hope for a comeback. Indeed, some believe conditions are ripe for America to vault over the international competition in a field seen as vital to economic success in the 1990's and beyond.

"We've got a tremendous opportunity to leapfrog limited technology and really develop a television of the future," said Dr. W. Russell Neuman, director of communications research at the media laboratory of the Massachusetts Institute of Technology.

"It would be a big mistake to write off the field," agreed Dr. Dimitris Anastassiou, a professor of electrical engineering at Columbia University who recently helped organize a technical symposium on high-definition television.

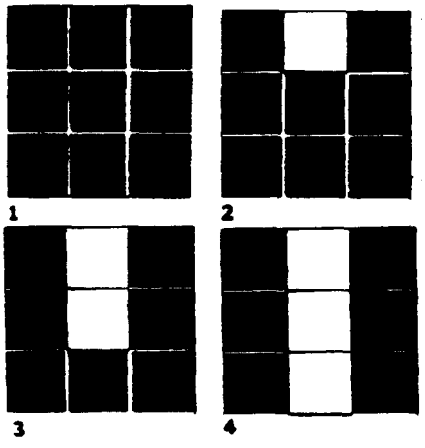
Experts say the main reason for hope is that the Japanese and Europeans, by virtue of an early lead, have locked themselves into a type of technology that may become antiquated. That technology is based on analog signals, which mimic the scenes and sounds observed by a camera and render these, in all their variations, as continuous electronic waves. The future of television, these experts say, increasingly lies in the direction of digital processing, the same technique computers use and is an area of great American strength. Digital signals turn the complexity of the real world into a code based on the numbers 0 and 1, or, in electrical terms, plus and minus. The code can be manipulated to process or transmit volumes of information with great accuracy.

"We have a hope because this country is so good in computers," said Dr. Arun N. Netravali, director of the computing systems research laboratory at the American Telephone and Telegraph Company's Bell Laboratories.

Pessimists say the race is already nearly lost, and that even if the United States came up with an innovative

Continued on Page C13

Producing Sharper Pictures With Less Data



A television image is produced when a beam of electrons repeatedly scans the screen, illuminating tiny pixels. Because high-definition television has more scanning lines, it needs more data than can be transmitted over normal broadcast channels. A new technique, conditional replenishment, gets around this problem by concentrating on the parts of the picture that are changing. The image is transmitted to a memory unit in the television set, which then transmits it to the screen. In the television picture above, only the moving parts of the woman's head, shown as light areas at right, are transmitted. In the four sets of pixels at left, only one pixel changes in each step from 1 to 4.

Continued From Page C1

design for a high-definition television, few companies would be able to make HDTV's now. They note that Zenith is the last large American company still in the television business.

The race for high-definition television is considered important by some experts because the technology may represent more than a path to sparkling images and sound as good as that on compact disks. Some experts see it creating a wide variety of new products, including video systems for education, industry, medical imaging and the military. Moreover, the technology is so demanding electronically, requiring scores of advanced new computer chips, that it is seen as a new driving force for the semiconductor industry, potentially providing even greater demand than computers do.

"The companies and countries that control the development of HDTV will have a huge lead in the coming competition for leadership in the electronics world," Representative Edward J. Markey, a Massachusetts Democrat who is chairman of the House subcommittee on telecommunications, recently said in opening a hearing on high-definition television. Other experts disagree, saying the importance of the field has been exaggerated.

A 20-Year Japanese Quest

Japan has long led the fledgling field, having embarked on HDTV research 20 years ago and investing an estimated $1 billion. European governments and companies over the past five years have spent about $200 million. Spending in the United States is estimated to be less than $100 million.

But both Europe and Japan have based their efforts on the development of analog systems that use wave-like transmission signals. These signals can easily be disrupted by static. Moreover, they are broadcast by satellites (Japan has one in orbit and Europe will soon) and are therefore not available to regular television viewers. Satellite transmissions aimed at a small geographic area or nation are relatively easy to accomplish. But experts say they cannot rival the economic advantages of terrestrial broadcasting that allows local programing and local advertising.

In contrast, the United States is focusing on the creation of what experts believe is a more egalitarian and economically promising system that could be broadcast over regular television channels. Moreover, there is growing enthusiasm about doing it with digital signals, which could dramatically cut distortion.

Several of the 20 or so American systems now under development are partly based on digital transmission, and American scientists at schools like Columbia and M.I.T. are racing to see how far digital technology can go in the search for the perfect television picture.

"As far as transmitting over the air, we're already way ahead of Europe and Japan," said William F. Schreiber, director of M.I.T.'s advanced television research program. "They simply haven't addressed the problem seriously." But some other

Pessimists point out that only one large U.S. company still makes TV's.

experts note that Europe and Japan have begun work on tackling the challenge of terrestrial broadcasting, instead of by satellite.

gfcrosslineMore Detail in More Lines

The basic goal of high-definition television is to increase the number of lines in a television picture, thus sharpening it. Today's television pictures in America and Japan are composed of 525 scanning lines, while those in Europe have 625. More scanning lines provide more details in the image on the screen. HDTV proposals call for various numbers of lines: 787, 1,050, 1,125, or 1,250.

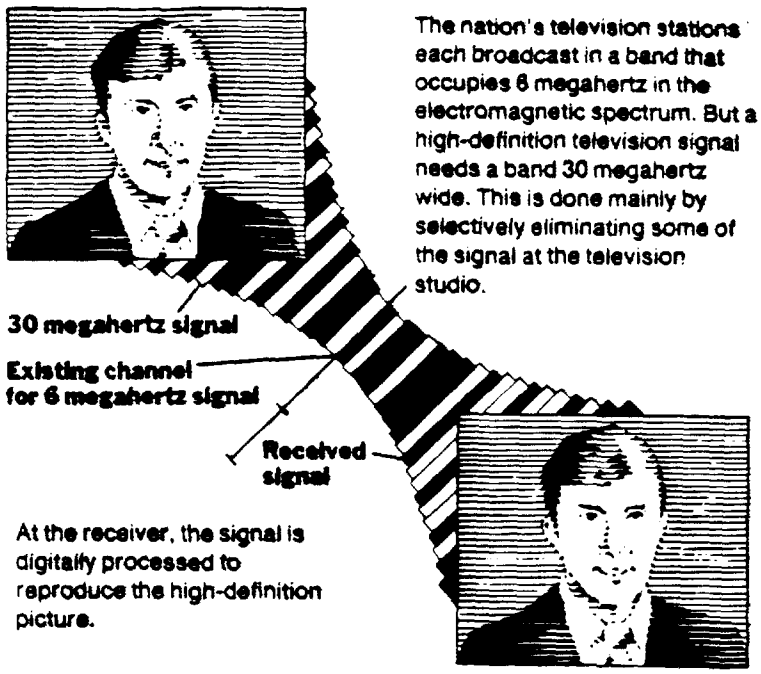
The challenge is not just making high-quality picture tubes. It also is devising a way to process and transmit all the extra information that is needed to animate the added scanning lines.

Last year, the Federal Communications Commission ruled that new American HDTV systems would not be allowed to make the nation's existing 160 million TV sets obsolete. That means broadcasters must give viewers the standard signal and, if they choose, the new HDTV signal for those who have special TV sets to receive it. In addition, the F.C.C. ruled that HDTV broadcasters must operate in the same wavelength range as older sets because the electromagnetic spectrum was considered too crowded to appropriate a new area.

In technical terms, the challenge is to squeeze the 30 megahertz of signal band width needed for high-definition television into the band of 6 megahertz for each channel that normal broadcasting uses. Some experts have likened the process to squeezing an elephant into a bathtub.

The solution is signal compression. It relies heavily on digital processing, which breaks the analog signals from

Fitting an Elephant Into a Bathtub



The New York Times/Ed Lipinski/Nov. 28, 1989

a camera into digital pulses that are sliced, diced and rearranged with incredible precision.

In a technique known as conditional replenishment, a series of images is digitally analyzed and only new features are transmitted, such as those that show an object moving. The static background is sent only once. Another technique reduces the data flow even further by taking into account the fact that the human eye perceives fewer details on a moving object than a stationary one.

"If you have a lot of motion, you don't send as much information," said Wayne C. Luplow, executive director of electronic systems research at the Zenith Corp., which is developing an HDTV system.

Elimination of Noise

Both Europe and Japan do some of this kind of digital signal compression. But then they switch back to analog signals for transmission to television sets, since that was the accepted approach when they started their work. In contrast, American scientists are working to extend the digital process all the way to the receiving TV set.

The advantage of digital transmission is error reduction. Electronic flaws, called noise, that invade an analog signal are sometimes nearly impossible to differentiate from the signal itself. But since a digital signal is made up of a string of simple pulses, noise stands out and is easily removed. In its place a computer can generate a corrected pulse after making a quick assessment of nearby pulses.

> Japan has spent $1 billion on research, the U.S. only one-tenth as much.

For instance, a black dot of interference could be replaced with a correct red dot of color, based on a survey indicating most nearby dots were red. Similar techniques of digital transmission are how deep-space probes send back stunning photos like those Voyager 2 recently radioed from Neptune.

"Digital communication by definition has higher fidelity," said Dr. Neuman of the Massachusetts Institute of Technology.

In addition, by going directly from digital processing to digital transmission, rather than switching back to analog, "You skip a step of processing, which improves performance and makes it more cost effective," said John I. Taylor, a Zenith spokesman.

The problem is that digital transmission is still only experimental. Researchers have tried over-the-air digital radio broadcasts, but are just starting to tackle the challenges of of over-the-air digital television.

Zenith, which recently decided to sell its personal computer business and focus on high-definition television instead, is one of the pioneers of digital transmission of HDTV. Its pro-

Europe and Japan gear up to eliminate U.S. advantage.

posed signal is a hybrid, part analog and part digital. The digital portion includes low-frequency video, the pulses that keep receivers synchronized with transmitters, and the audio signal for high-quality stereo sound. The analog signal contains high-frequency video information, which helps make up the picture.

An important advantage of this approach, Zenith says, is a vast reduction in the amount of power needed for the broadcasting transmitter, since the low-frequency part of the analog signal that has been eliminated is also the power-hungry part. Zenith's HDTV signal, it says, uses less than 0.2 percent of the power needed for regular transmissions.

This power reduction, in turn, allows Zenith's HDTV signal to use the channels that usually are empty in crowded city television markets. Because analog signals are so strong, they can be broadcast only by skipping channels between them so they do not interfere with each other. For instance, a city with several stations might have channels 3, 5, 7 and 9 in use. But the low-power Zenith signal can be broadcast in the taboo channels in between without causing interference.

Scientists say proposals like Zenith's are but the first step on the digital highway, and that the transmission journey might be complete in the next 5 to 10 years.

"Over the air, if you can receive it, digital will have the advantage of being perfect," said Dr. Anastassiou of Columbia University. He noted that there are a host of challenges.

It will be at least two years before the Federal Communications Commission decides on standards for over-the-air HDTV broadcasts. Some options under study would make it easier to extend the digital range; others would make it harder.

Some scientists say a better digital route is through a national network of glass fibers that connect homes. Such fibers can carry enormous amounts of digital information in the form of laser-light pulses, transmitting not only digital HDTV signals to American homes, but also other types of information, including high-speed computer data.

"We want to make this the superhighway of the future," Jules A. Bellisio, a fiber enthusiast at Bell Communications Research in Redbank, N.J., told the recent HDTV symposium at Columbia.

Finally, scientists say, the advent of digital television will aid the merging of computers and television, with the prospect of a rush of combined uses. Smart TV's, for instance, could automatically scan the digital airwaves for shows of interest, recording them when certain key words were present.

Several scientists and engineers warned that American HDTV would materialize only if there was steady Federal financial support for the field. Most direct in his comments was Dr. Neuman of M.I.T., who said, "The lack of leadership in the Bush Administration may blow it."

On the other hand, some experts say, HDTV development could prove so successful in the United States that it would be exported to the countries now considered the leaders.

"There's a lot of interest in Japan and Europe for terrestrial broadcast systems," said Mr. Luplow of Zenith. "We think that when there is a terrestrial standard in the United States, it may be adopted in those countries as well."

TELE-COMMUNICATIONS, INC.

FOR IMMEDIATE RELEASE

CONTACT: Bob Thomson 303-721-5220

MAY 16, 1989

TCI SAYS IT IS READY TO BEGIN FIRST STEP OF TWO PART STRATEGY TO PROMOTE AMERICAN HDTV

In testimony to the Subcommittee on Science, Technology and Space of the U.S. Senate Commerce Committee, John J. Sie, Senior Vice President of Tele-Communications, Inc., urged adoption of a two-part plan to promote American HDTV for the benefit of American viewers and to give the U.S. a chance to regain its global competitiveness in home electronics technology:

(1) Deploy as soon as possible (within two years) an existing American analog-based HDTV system that uses and is fully compatible with the current 6 MHz NTSC standard;

(2) "Leap-frog" foreign HDTV competition and develop by the year 2000 an American 6 MHz processed digital HDTV system.

Separately, Mr. Sie announced that within a year TCI and other cable operators will invite national cable and broadcast programmers and local broadcasters to join in a full scale operational test of regularly scheduled programs on the analog-based HDTV, 6 MHz NTSC-compatible, Faroudja Super NTSC system.

This test will show viewers through public demonstrations across the country the benefits of HDTV, while giving U.S. television set manufacturers the incentive to produce Super NTSC receivers for sale or rental (as early as 1991). TCI also hopes the test will assist the FCC to decide upon an HDTV terrestrial broadcast tranmission standard.

Sie explained in his testimony to the Subcommittee that with Super NTSC, "Americans will be able to receive improved pictures even on their existing television sets -- and there are 160 million of them -- because it reduces NTSC artifacts (wiggles) and color distortions."

"U.S. technology can provide America with an HDTV system with a picture quality second to none and which can be implemented more quickly and economically than any foreign system" Mr. Sie emphasized.

Mr. Sie noted that TCI was very encouraged by the progress of Faroudja's NTSC system in the last few months, including successful demonstrations to American and Japanese broadcasters and a successful test on a TCI cable system in Sunnyvale, California.

"But the real game is for the long-term," Sie added. "The NTSC standard lasted 40 years and has served us well. Any HDTV standard should be similarly robust. We believe the next generation of HDTV should be a processed digital system which will enable transmission of a digital signal within 6 MHz so that broadcasters can continue to fulfill their historic role in

promoting localism. Moreover, this leap-frog strategy utilizes U.S. strengths in computer, microprocessor chips and software technology."

Accordingly, Mr. Sie urged the United States to set a national goal of developing and deploying a processed digital system which "could provide HDTV over broadcast stations and cable by the year 2000."

Mr. Sie further noted that those who argue that simple digital is good enough are not being practical because it requires so much television spectrum to transmit the signal it would mean the end of local broadcasters. The only way American viewers could receive television signals would be through direct broadcast satellites and fiber optic cable."

The problem, Mr. Sie said, is that "the current best estimate to lay fiber universally to American households is twenty to thirty years -- if ever. We cannot wait that long because foreign competition will have long since established dominance in our marketplace."

Mr. Sie reminded the Committee that "the cable television industry serves more than 55% of American households. This gives us and our viewers a vital stake in any HDTV deployment."

TESTIMONY OF

JOHN J. SIE

SENIOR VICE PRESIDENT

TELE-COMMUNICATIONS, INC.

ON

DEVELOPING A NATIONAL TECHNOLOGY STRATEGY FOR HIGH DEFINITION TELEVISION

BEFORE THE

SUBCOMMITTEE ON SCIENCE, TECHNOLOGY & SPACE

COMMITTEE ON COMMERCE, SCIENCE AND TRANSPORTATION

U.S. SENATE

MAY 16, 1989

Introduction

My name is John J. Sie and since 1984 I have been Senior Vice President of Tele-Communications, Inc. (TCI), a cable company headquartered in Denver, Colorado, which operates cable systems throughout the country.[1] TCI also has invested in cable programmers in furtherance of its commitment to provide American cable viewers with a wide range of quality entertainment and information programs in addition to retransmitted over-the-air programming. At TCI, I am responsible for strategic planning, public policy and program investment.

Approximately 55% of American television households (49.5 million) receive their television signals through a cable system. Accordingly, the cable industry is vitally interested in proposals regarding HDTV and we appreciate the opportunity to testify this morning. (I will use HDTV in the same general way the the FCC uses ATV.)

---

[1]Frankly, I have been a "closet technocrat" for the last 15 years. My education and early career development were technical. I received my Bachelors degree in Electronics in 1957 from Manhattan College and my Masters degree in electrophysics from the Polytechnic Institute of Brooklyn in 1958. My technical career started in 1958 at RCA's Defense Electronics Division as a senior member of Technical Staff, working on microwave solid state devices for troposcatter and satellite communications. In 1960, I co-founded and was later President of MicroState Electronics Corporation, a subsidiary of Raytheon Company. Microstate did R&D and manufacturing work for the space and defense industries in areas of advance solid state devices for missiles, radars, and telecommunications. In 1972, I joined the Jerrold Subsidiary of General Instrument Corporation where I developed two-way interactive cable TV, multi-channel and addressable pay-per-show TV scrambling systems. In 1977, I joined Showtime Entertainment, a subsidiary of Viacom International, Inc., as Senior Vice President of Marketing and Affiliates. Showtime is in the business of providing movie based pay-TV services primarily to the cable industry.

The Importance Of HDTV

As Chairman Gore and the other members of this Subcommittee have recognized, HDTV means more to America than television pictures with video quality comparable to 35 mm film and with compact disc quality sound. Over the longer term, there also are expected to be many non-entertainment uses for the high resolution video technology, including: interactive education; computer work stations; satellite photography; defense command and control displays; advanced weapons targeting; and medical diagnostics. Most importantly, if the U.S. Government takes the right actions, then American HDTV in the 21st century will use the most advanced integrated circuits and computer processes in a home environment. Whoever takes the lead in HDTV technology will have the advantage with respect to key components (semiconductors, etc.) and in related areas of computers, software and test equipment.

In short, we applaud the Commerce Committee for its recognition that the HDTV competition represents a bigger challenge to our technological leadership in the world than did the color television or the VCR. Decisions made now will affect our place in the world well into the next century.

What The U.S. Government Should Do

The noted management consultant, Peter Drucker, has been quoted as saying that a competitor should never try to catch up -- instead he should "leap frog" the current leader. We could not agree more.

Specifically, we call upon the U.S. Government to:

(1) set a national goal of introducing by the year 2000, an American "processed digital" HDTV system which permits the transmission of a digital-HDTV signal within 6 MHz;

(2) support efforts already underway in the private sector to develop and implement a processed digital transmission system;

(3) promote the introduction within two years of an interim analog-based HDTV system which uses the current 6 MHz NTSC standard, so that the more than $100 billion invested in broadcast and cable transmission equipment, television sets and VCRs will not be rendered obsolete;

(4) reserve frequencies allocated for television broadcasting, but not currently utilized, for processed digital HDTV during the transition period when broadcasters will simulcast compatible analog HDTV and non-compatible digital HDTV signals.

These combined actions will:

- thwart attempts by foreign countries to introduce non-compatible HDTV systems in the U.S.;
- ensure that American viewers have access to improved television pictures quickly;
- minimize the cost and disruption associated with introducing HDTV; and
- maintain the ability of American broadcasters and cable operators to provide local and national news, information and entertainment programming.

Why the U.S. Should Focus On Digital-Based HDTV

Analog-based HDTV systems will not be competitive in quality or cost with the next generation of digital-based HDTV systems. For the purposes of television signal transmission, "digital" simply means converting an analog HDTV waveform to a series of binary bits of 1's and 0's.

Digital-based HDTV will offer the same revolutionary advancement we have achieved, by way of analogy, with compact discs and digital audio tapes versus standard LP's. A digital signal:

- suffers from no transmission degradation;
- enables true studio quality image and sound in American homes;
- permits direct integration and signal manipulation between the home television and home computer; and
- promises volume-efficient cost reductions in manufacturing digital HDTV sets.

Furthermore, developing an American digital-based HDTV system lets us "leap-frog" the Japanese MUSE and European EUREKA HDTV systems which are analog-based transmission systems. U.S. entities have the lead in developing digital-based technology. This work both relies on and contributes to the U.S. leadership position in VLSI circuits, micro processors, software systems and adaptive compression techniques.

Why the U.S. Should Focus On a "Processed Digital" System

1. What is "Processed Digital"?

A "processed digital" HDTV transmission system can be defined as any digital-based HDTV television transmission system which reduces the frequency spectrum required to transmit a signal by taking into account three major factors:

a) standard digital compression transmission techniques; and

b) the specific nature of the video waveform; and

c) the neural responsiveness of the human eye.

2. A "Brute Force" Digital Approach Employs Only Standard Digital Compression Transmission, Requires Excessive Spectrum, and Would Terminate Local Broadcasting

Before discussing the design of processed digital, let's first look at transmission systems which only use standard digital compression techniques.

Digital telecommunication systems today routinely exhibit bandwidth compression efficiencies of 4.5 Bps/Hz: for every 4.5 bits of data, we need only one cycle of radio frequency (RF) spectrum to transmit them. For example, a 4.5 Mbps data stream can be transmitted using only one MHz of RF bandwidth. Most

digital long-haul microwave transmission systems achieve this compression efficiency using a 64-level quadrature amplitude modulator (QAM). As higher levels (256 - 1024) become available on the market, further bandwidth compression of up to 7.5 Bps/Hz is possible with appropriate error corrections..

Now let's design an HDTV system with the following characteristics: (1) a resolution of 1050 x 1050, i.e., the whole screen is capable of resolving into small cells called "pixels," 1050 vertical by 1050 horizontal so that the total number of pixels per screen is 1,102,500; (2) the screen is scanned at a rate of 30 times per second (in order to show continuous motion) with a 2:1 interlace scan; and (3) there are 5 binary bits of information each required to define the intensity (luminance) and color (chrominance) content for each pixel. The total amount of digital information needed to be transmitted every second in this system is 1,653,750,000 bits! Even using a transmission compression of 7.5 Bps/Hz, the required RF spectrum is 220.5 MHz for just one channel of HDTV programming!

Such a "brute force" approach using so much spectrum for digital HDTV is not suitable for over-the-air transmission: there simply is not enough spectrum available without creating new demands on other spectrum users (e.g., land mobile radio, public safety radio, etc.)

This is a serious drawback: it effectively would mean the end of the local broadcastings in the HDTV arena. Local broadcasting has been a hallmark of American television policy since its inception.

The only way to transmit such signals would be through fiber-optic cables. But it would be extremely expensive to install such cables throughout the country and telephone companies would not be able to lay fiber universally to every American home until well into the 21st century. In addition, there are serious technical questions about even the feasibility of transmitting more than a few HDTV channels requiring such great bandwidth even with fiber-optic cable: within the foreseeable future, the state of the art in video switching using sub-micron integrated circuit technology is below 1 Gbps, or at best each video switch at the remote terminal can only handle 4 HDTV channels. Moreover, at a 1 Gbps switching rate, the cost of such switches are not going to be competitive at all.

3. A "Processed Digital" Approach Greatly Reduces The Necessary Bandwidth

The brute force digital approach described above, utilizing 220 MHz bandwidth, is capable of faithfully reconstituting all ranges of intensity and color for every pixel for every frame. But it is not necessary to do so given the nature of video images and the limitations on the ability of the human eye to perceive such information.

Even with the most detailed scene and fastest motion, much of the content information from pixel to pixel and from frame to frame does not change. (A crude example of my point can be seen by advancing a videotape on a VCR frame-by-frame.) Therefore, instead of sending each pixel of each frame new information every time, the processed digital system only sends new information when there is a change. By doing so, much less transmission spectrum is needed.

Furthermore, the pixels can be grouped into cells of several pixels each, further reducing the necessary bandwidth. A receiver can have the adaptive capability of interpolating the proper information for each of the pixels in each group from the coded "change" information being received and processed. The reconstituted image will be perceived by the viewers as having the full resolution.

Because of these factors it is possible to drastically reduce further the spectrum needed -- that's the "Processed Digital" approach. Indeed, we believe that a processed digital signal need not require more RF spectrum to transmit than the current NTSC signal.

We engaged Hatfield Associates, Inc. (HAI), under the direction of Mr. Dale Hatfield, to assess the likelihood that, over the next ten years or so, a processed digital HDTV signal could be transmitted via terrestrial broadcasting and cable systems within a 6 MHz RF bandwidth. Their conclusion is that even using today's

available technology, such a goal can be achieved. (For the Subcommittee's reference, the March 20 Hatfield Assessment and March 28 Addendum are attached.)

In the very near future we hope to bring together the best scientific minds in this country to review this conclusion and to discuss how it can be achieved!

Work is Already Underway Around the Country on Processed Digital

Many scientists in research labs and industrial enterprises are hard at work developing different variations of the processed digital approach.

This, of course, has been the traditional American way of engineering: separate and competing laboratories. However, given the national importance of developing an American processed digital HDTV system, we believe it would be appropriate for the Federal Government to assist these efforts.

Of note are Professors William Schreiber and Andy Lippman of MIT's Media Lab, Arun Netravali and Barry Haskell of AT&T Bell Laboratories, and Arthur Kaiman and Lawrence Ryan of Intel's DVI Program in Princeton, New Jersey.

DVI's work is particularly interesting. It is an advanced technology which combines the interactive graphics capabilities in personal computers with high-quality television and multitrack audio in an all-digital integrated system. At the heart of the system is a proprietary chip set with a unique video compression algorithm. A technical breakthrough in compression efficiency was

announced by DVI in 1988 -- they can microcode one hour of full NTSC television programming on one CD-ROM disk, heretofore thought to be impossible. The chip set and the associated operating software can be in three plug-in boards to PC/AT computers. The DVI system is used for interactive video program designs. It has a real time video compression capability of 30:1 by removing redundant pixel to pixel information within each video frame. This is called intraframe coding. Once the interactive video/date/audio application program is completed, the program can be further compressed by removing interframe redundant information. This would require much more computing and storage capacity and is done off line. Interframe coding of DVI technology can offer another 4:1 compression yielding a final CD-ROM disk containing 1 hour or NTSC video with 120:1 compression.

Although the DVI's current application is institutional for education and training, and the cost of the prototype system is about $25,000, it is not hard to project what can be done as we continue to improve processed digital, transmission compression, and cost reduction of large capacity memory storage devices in the next 10 years. (Consider: Intel's workhorse microprocessor 80386 has computing capacity similar to the IBM large mainframe computer 360/50 of twenty years ago! Intel is already developing the next generation microprocessor with at least 10 times more capacity than the 80386.)

Quantitatively, a 1.65 Giga bits per second of digitized HDTV signal with a video compression of 120:1, a transmission modulation

compression of 5:1 and a 33% capacity for forward error correction would need only 3.65 MHz!

The U.S. Should Promote the Introduction Within Two Years of an Interim Analog-Based American HDTV System Which Uses the Current 6 MHz NTSC Standard

Japan's MITI and its National Broadcasting Company (NHK) have been trying hard to persuade U.S. policymakers that they are the only ones with a HDTV system and are ready and able to make it available to U.S. consumers. What they downplay is that their system is incompatible with existing U.S. television transmission equipment (broadcasting and cable) and television receivers, all of which work with the current NTSC standard of 525 lines, 59.94 Hz frame rate, 4:3 aspect ratio, and 6 MHz transmission standard. Thus, it is not hard to see the Japanese's true objective: the sales of new Japanese HDTV sets full of Japanese components. Yet, there is no need to suffer such problems.

An American HDTV system exists now (Faroudja's Super NTSC) which is NTSC compatible and provides as sharp a picture as the full, original MUSE system for the largest of American television screens (six-foot diagonal).[2] The improved effect of the analog

---

[2]Since the FCC's tentative decision last year requiring compatibility with NTSC receivers, NHK has tried to modify its MUSE system. But picture quality has been significantly sacrificed, the system is expensive, and even the Japanese terrestrial broadcasters don't like it!

HDTV signal only appears on new television sets; but Americans will be able to receive improved pictures on the existing 160 million television sets because Super NTSC reduces artifacts (wiggles) and color distortions. Moreover, costs of a new Super NTSC TV set will be less than that of alternate systems because of its compatibility with the NTSC standard and successful use of VLSI chips.

Importantly, because broadcasters and cable operators can easily send the more advanced signals over the same bandwidth as an NTSC signal, the number of programs with a sharper image and digital quality sound available to the viewer is maximized. Maintaining the current 6 MHz transmission standard also permits broadcasters and cable operators to continue fulfilling their important role in providing local coverage.

The immediate and universal availability of the best in broadcast and cable programming in 35 mm picture quality and compact disc sound with reasonably priced HDTV sets will capture the consumer market and blunt the threat of incompatible foreign VCR's and TV's with questionable "software" (recall the commercial flop of Super 8 and Super VHS for the same reason).

In just the last few months, Faroudja has successfully demonstrated the Super NTSC system in a variety of settings.

In February, 1989, Faroudja was invited to Japan by their privately owned commercial broadcast networks. These networks are understandably resentful of NHK's plan to bypass terrestrial

broadcasters for HDTV by DBS, VCR and video discs. Moreover, since it is becoming clear that the Europeans, and now the U.S. will not accept the MUSE system, they are increasingly less willing to sacrifice for any "greater good." They invited Faroudja because his Super NTSC system is better and more advanced than their own NTSC compatible HDTV systems. Faroudja's demonstrations were a hit: he stayed longer and had far more attendees than had been expected.

A month ago, Faroudja successfully demonstrated Super NTSC on a TCI cable television system in Sunnyvale, California. The experiment involved side-by-side comparisons of a standard NTSC signal transmission and the Faroudja Super NTSC transmission through the Sunnyvale cable system to receivers in City Hall. The result was a remarkable improvement in picture quality when using the Super NTSC process. Frank Haney, a technical executive with Capital Cities/ABC, watched the demonstration as an invited, objective observer, and concluded that "Super NTSC looked more like film that TV." (A copy of his comments on the demonstration is attached.)

At the NAB convention at the beginning of this month, Faroudja demonstrated his system with a UHF transmission with digital sound -- again to rave reviews. The Super NTSC signal was broadcast throughout the Las Vegas area and received on standard NTSC receivers as well as HDTV receivers at the Convention.

Finally, Mr. Chairman, I want to note that John Malone, President and CEO of TCI, announced at the NAB convention that

within one year, at a site to be selected, TCI plans to invite local broadcasters to join in a major operational test of this analog, NTSC-compatible, HDTV system. TCI will equip its cable system in the locality with the necessary equipment and will actively seek one or more local broadcasters who would be willing to invest in transmission equipment as well. Moreover, if computer chip and U.S. television set manufacturers are willing to cooperate, we believe a limited number of modified HDTV sets can be available to consumers in the test locality for rent or purchase by the end of 1991.

In short, maintaining the current 6 MHz NTSC standard for analog-based HDTV will bring sharper pictures with a greater number of programs to more American viewers in the shortest time and at the lowest cost.

The U.S. Government Should Reserve Unutilized Television Frequencies for Simulcast of Analog and Digital HDTV Signals

As we have explained, there is no need to deviate from the existing 6 MHz transmission standard in order to bring the benefits of HDTV to the American public.

Yet, in September, 1988, the FCC left open the possibility of changing the standard for HDTV broadcast to permit the use of up to an additional 6 MHz -- as long as the additional bandwidth was found within the spectrum currently allocated to television

The problem is that permitting analog-based HDTV signals of more than 6MHz within the existing television spectrum would be impractical and disruptive, requiring costly channel reallocations and preempting available spectrum for the next generation of digital-based HDTV systems.

Remember: the ultimate goal is adoption of a digital-based HDTV signal. This necessarily will be incompatible with any analog television set. Thus, there must be a transition period. By reserving frequencies allocated for television broadcasting, but not currently utilized, for processed digital HDTV during this period, broadcasters will be able to simulcast compatible analog HDTV and non-compatible digital HDTV signals. Thus, the United States will be able to make the transition easily, with minimum cost and disruption, to a processed digital system that will serve us well into the 21st century -- just as the NTSC standard has served us well in the last 40 years.

Conclusion

We at TCI believe that a very intense, well coordinated and well financed effort, bringing together the best minds in video processing, film technology, VLSI, solid state memory technology, microprocessor software, bio-engineering, visual psychophysics, and visually creative programming expertise would rapidly accelerate the state of the art to bring the most advanced, competitive, and cost effective processed digital HDTV system for the 21st century.